Third Chapter
CHAPTER 3

THE STUDY AREA

3.1 Introduction

Mahi Right Bank Canal Command Area in Anand and Kheda districts of Gujarat state (India) is one of the major irrigation projects taken up immediately after the independence. The irrigation system has helped a high agricultural growth in the command area. It is supplied with the water from Wanakbori weir located downstream of Kadana dam on the river Mahi. The main canal is 73.6 km long while there are six branch canals; namely Nadiad, Petlad, Borsad, Cambay, Limbasi and Matar branch, measuring a total length of 223 km. The MRBC area falls between Latitude N 22° 14’ – N 22° 55’ and Longitude E 72° 22’ – E 73° 18’. The Culturable Command Area (CCA) of the MRBC is 212694 hectares. It is bounded by the Mahi river on the east, Shedhi river on the north, Watrak and Sabarmati rivers on the west and the Gulf of Cambay towards the south. Though faced by water logging problems in the initial years, development of groundwater-based irrigation through tubewells has helped in addressing this problem to the large extent. Fig. 3.1 (a) - (c) shows the location of the MRBC command area.

Matar branch canal command area of MRBC, as shown in Fig. 3.1 (d), is selected as the study area. It lies between N 22° 36’ 34” – N 22° 44’ 45” Latitudes and E 72° 31’ 45” – E 72° 52’ 17” Longitudes. Matar Branch Canal bifurcates from Nadiad branch canal of MRBC near Nadiad town and has a GCA of about 23800 hectares. It serves the CCA of 13176 hectares in Matar and Nadiad Tehsils of Kheda district. Matar branch canal is 19.39 km long and its Traj distributary 19.82 km long, supply water to the tail part of the command area in south east.

The river Shedhi forms the northern boundary and the river Watrak forms the eastern boundary of the study area. These rivers are the seasonal rivers and carry the residual flow of the tail end canals during the most part of the year. It is observed that the
canal water supply during the hot-weather season mostly remain closed in the command area. This practice promotes the use of groundwater for irrigation in the hot-weather season.

Fig. 3.1 Location map of the study area
3.2 Climate

The climate of the MRBC command area is semi-arid, with four distinct seasons. The cold season from December to February is followed by hot summer from March to the middle of June. The period from mid June to September is the south-west monsoon season. October and November constitute the post monsoon season characterized by moderate temperature and scanty rain. The average annual rainfall is about 823 mm and there is substantial spatial and temporal variation in annual rainfall from year to year. May is generally the hottest month while January is generally the coldest month.

3.3 Topography

The MRBC command area is characterized by the flat topography with high spots and ridge in the central and northern-eastern regions. The land slopes from north east to south west with an average gradient of about 1 in 1600. The south west region comprises a relatively flat land and is locally referred to as Bhal area. The Digital Elevation Model (DEM) generated for MRBC command area is presented in Fig. 3.2. The unique feature of the command area is that natural surface drainage is inland. There are a large number of local depressions with varying areal extent in the command area wherein water gets collected. The water stored in these depressions has served as the source of water for drinking and irrigation purposes. The Matar branch command area comprises several watersheds of the rivers Shedhi, Watrak and Sabarmati which surround the command area and those of the inland depressions. The banks of all these rivers are nearly vertical giving the command area a table land appearance.
3.4 Drainage system

The MRBC command area is surrounded by Mahi river on the east, Shedhi river on the north, Watrak and Sabarmati rivers on the west and Gulf of Cambay towards the south. The small rivers, namely Luni and Mohar flow in the north-eastern part of the command area before joining the Shedhi river near Nadiad. There are large numbers of artificial drains constructed by the Irrigation Department, Government of Gujarat (GOG). A widespread network of artificial drains measuring the total length of 1627 km comprises of 539 km long main drains and 1088 km long lateral and sub-lateral drains (MIC, 2007). Though, the capacities of the artificial drains are not sufficient to carry the runoff from the present trend of the rainfall and some parts of the command area are flooded during events of the heavy rainfall.
3.5 Soils

The entire MRBC area was formed by alluvial deposits carried by Mahi, Sabarmati, Watrak and Shedhi rivers. During the process of alluvial formation, the coarse and heavy materials were deposited near the source where as the finer materials that are carried away towards the Gulf of Cambay form the clay soil deposits in the flat region near the coastal estuaries. These deposition patterns have manifested in distinct soil color tones in the area. In the north eastern part, soils are coarse grained, mostly comprising sand and silt. It becomes finer towards south west and found heavy black and clayey type in Bhal region (CGWB, 1995). Fig. 3.3 shows the soil zones in MRBC Command area. Zone-I represents well-drained non-calcareous sandy loam soil with low salinity in the upper reaches of the area. In the middle reaches of the area, soil type Zone-II is found which varies from sandy to clayey soils with relatively high salinity. Zone-III consists of imperfectly drained clayey soils with relatively high salinity present in the tail lower reaches. Most of the Matar branch canal command area falls within soil Zone-II. The intensive irrigation in the area has led to increase in soil salinity.

![Soil zones in MRBC command area](image)

**Fig. 3.3** Soil zones in MRBC command area
Table 3.1 shows the groundwater salinity scenario in MRBC area during different periods of the project. There is 78.3 % area with EC values less than 2250 micromhos/cm in the year 2009 (pre-monsoon) as compared to 59 % area in the year 1981 (pre-monsoon). However, 48.5% of the MRBC command area has EC values exceeding 2250 micromhos/cm, during the year 2009 (post-monsoon), which shows the severity of groundwater salinity.

Table 3.1 Distribution of MRBC area under various ranges of salinity of groundwater

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Salinity Ranges EC (micromhos/cm)</th>
<th>Pre-monsoon 1981</th>
<th>Pre-monsoon 2009</th>
<th>Post-monsoon 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (hectares)</td>
<td>(%)</td>
<td>Area (hectares)</td>
<td>(%)</td>
</tr>
<tr>
<td>1</td>
<td>0 – 250</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>250 – 750</td>
<td>3429</td>
<td>1.0</td>
<td>22460</td>
</tr>
<tr>
<td>3</td>
<td>750 – 2250</td>
<td>183811</td>
<td>58.0</td>
<td>191060</td>
</tr>
<tr>
<td>4</td>
<td>2250 - 5000</td>
<td>73991</td>
<td>24.0</td>
<td>46970</td>
</tr>
<tr>
<td>5</td>
<td>&gt; 5000</td>
<td>54559</td>
<td>17.0</td>
<td>12120</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>315790</td>
<td>100</td>
<td>272610*</td>
</tr>
</tbody>
</table>

* Including area beyond Alang drain total GCA = 272610 + 43180 = 315790 ha
Source: Gujarat Engineering Research Institute, Vadodara, Report: 2009-10

3.6 Hydrogeology

The top layer of the MRBC aquifer consists of the recent to sub recent alluvium related to the sediments brought by the rivers Mahi, Shedhi, Vatrak and Sabarmati. The thicknesses of alluvial deposits are estimated to vary between 30 to 150 m from east to south west. The alluvium consist of silt, clay, sand and pebbles in various proportions. Fig. 3.4 shows the hydro-geological section across the study area. The underneath rock is of Gaj Deccan trap and Godwana formation such as limestone, clays, basalt, dolerite, coarse sand stone, grit, conglomerate and shales. MRBC command area lies in the Cambay geo-hydrological basin.
The pump test carried out in the command area to estimate the aquifer properties indicate high coefficient of permeability and transmissivity, with the higher values in the eastern part and lower values in the western part. The irrigation facilities in the area for more than fifty years have resulted in the rise of groundwater table. Table 3.2 shows the sub-soil water table condition in the command area before the inception of the project in 1958 and Pre-monsoon and Post-monsoon periods of the year 2009. There is about 5% of the MRBC command area having water table level within 1.5m and 21% area having water table level within 3m from ground level after monsoon in the year 2009. This situation is indicative of the very high levels of water table and area is prone to water-logging conditions.
Table 3.2 Behavior of sub-soil water table in MRBC area

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Depth to water table (m)</th>
<th>Year 1958 (Before project)</th>
<th>Year 2009 (Pre-monsoon)</th>
<th>Year 2009 (Post-monsoon)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Area (GCA) (hectare) (%)</td>
<td>Area (CCA) (hectare) (%)</td>
<td>Area (CCA) (hectare) (%)</td>
</tr>
<tr>
<td>1</td>
<td>Within 1.5</td>
<td>Nil 0.1</td>
<td>270 10.2</td>
<td>13090 4.8</td>
</tr>
<tr>
<td>2</td>
<td>Between 1.5-3.0</td>
<td>2643 1.0</td>
<td>27570 10.2</td>
<td>45340 16.6</td>
</tr>
<tr>
<td>3</td>
<td>Between 3.0-6.0</td>
<td>27058 9.0</td>
<td>89235 32.7</td>
<td>79570 29.2</td>
</tr>
<tr>
<td>4</td>
<td>More than 6.0</td>
<td>286089 90.0</td>
<td>155535 57.0</td>
<td>134610 49.4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>315790 100.0</td>
<td>272610 100.0</td>
<td>272610 100.0</td>
</tr>
</tbody>
</table>

Source: Gujarat Engineering Research Institute (Report 2009-10), Vadodara

3.7 Rainfall

Mahi Right Bank Canal Command area has arid to semi-arid climate with average annual rainfall 823 mm. More than 90% of the rainfall occurs in monsoon season (June-September). A widespread network of nine rain gauge stations exists in MRBC project area and long term rainfall data record is available. The long term average annual rainfall computed for Matar station in the study area is 753 mm with large variability in annual rainfall. The average number of rainy days in a year is found to be 34 signifying the concentrated rainfall with long dry periods in the study area. Locations of the rain gauge stations existing in the MRBC command area is shown in Fig. 3.5.

3.8 Surface Water Resources

The topography of the MRBC command area is relatively flat with low-lying areas within. The runoff water is discharged through the drainage system in Mahi, Shedhi, Watrak and Sabarmati rivers. There are large numbers of small village tanks in most of the villages wherein the water from the surrounding areas accumulate and villagers use it for their livestock and domestic requirements. There exist few large tanks in the south-west part of the MRBC area, namely Pariej and Kanewal which are used for water supply schemes and even for irrigation purposes. In the Matar branch canal command
area, there are three tanks namely; Chokadia, Patel and Salla tank fed by minor canals of the Traj distributory and the water is used for the irrigation purpose in the surrounding areas.

![Map of the MRBC command area](image)

**Fig. 3.5** Location of rain gauge stations in MRBC command area

### 3.9 Land use

There is a high population density in Anand and Kheda districts of Gujarat state wherein MRBC project exists. The area is well connected with major roadways and railways, giving rise to the industrial development. MRBC command area comprises of 315790 hectares GCA with 212694 hectares of CCA. With irrigation water availability, CCA is extensively used for growing crops almost throughout the year. Some part of the CCA has been converted to the non-agricultural land for the developmental activities in the area, such as housing, roadways and industrial use. Though the area has no forest cover, there are large numbers of trees existing in the agriculture land, along roads sides and canals banks.
3.10 Agriculture and Cropping Pattern

The main Kharif crops in the command area are paddy (*Oryza sativa*), jawar (*Sorghum bicolor*), bajara (*Pennisetum americanum*), pulses, potato (*Solanum tuberosum*), tobacco (*Nicotiana tabacum*), castor bean (*Ricinus communis*) and vegetables. The main crops in the Rabi season are wheat (*Triticum aestivum*), tobacco (*Nicotiana tabacum*), pulses, ground-nut (*Arachis hypogaea*) and vegetables. The hot weather crops are paddy, bajara, pulses, ground-nut and vegetables. Assured irrigation facilities have encouraged farmers to cultivate the crops throughout the year and to change over to more water consuming crops like paddy. Cropping pattern has changed with the development of hybrid seeds, advancement in agro-techniques and changes in market prices of the crops. Rise in groundwater levels and land salinization has also affected the cropping practices to a large extent. Area of paddy cultivation has increased manifold as compared to the cultivation of other crop.

3.11 Field Visits and Questionnaire survey for Study Area

A large scale water resources project bring positive changes like revolution in agricultural production by increasing it manifold, up trend in economy and urbanization along with negative ones like environmental degradation, water-logging and salinization of fertile land, problems associated with human health and so on. The surface irrigation project like MRBC has also resulted in positive and negative impacts on agricultural, environmental, industrial, health and socioeconomic sectors. The intensive irrigation in the area for more than five decades has resulted in the considerable rise of groundwater levels. Soil salinity has also increased to a level which causes reduction of crop yield and land degradation. The rise in groundwater levels and soil salinity has caused social and economical problems in some parts of the study area.

A survey was carried out to understand the present status of the impact of MRBC irrigation project on farmers in Matar branch canal command area. Nine villages namely; Garmala, Machhiel, Heranj, Traj, Haijarabad, Undhela, Sandhana, Alindra and Raghwanaj were identified from the study area affected by water-logging for the survey. The locations of the selected villages for the survey are shown in Fig. 3.6. Door to door
contact of total 83 families of the farmers in these villages was made during Dec. 2009-Jan. 2010 and their responses in the questionnaire were collected to understand and analyze the socio-economic conditions in the area. The questionnaire (Appendix-I) included the queries related to area of land owned, its productivity, area of land affected by water-logging and/or salinity, average yearly income, farm equipment used, livestock owned, educational status of the family members, health problems and their overall assessment of the land condition.

Fig. 3.6 Location map of the villages selected for the survey

3.11.1 Analysis of questionnaire

The responses from the farmers were analyzed to understand the socio-economic conditions in the study area. The survey revealed that the socioeconomic changes have occurred in the study area in the last three decades. The number of farmers with small land holding has increased. There are 24% of the farmers with land holding less than 4 hectares, 65% with land holding between 4-15 hectares and 11% farmers having land holding more than 15 hectares. It is reported that 12% of the land owned by the farmers is affected by water-logging and 22% land is affected by the soil salinity. The livestock has also, been affected due to stagnant water pools around the villages. The large scale breeding of the mosquitoes has affected the health of the livestock. During the visit to the study area for survey, water-logged areas were witnessed in many villages. The area affected due to water-logging in village Garmala (Ta. Matar) is shown in Plate 3.1. Plate
Plate 3.1 Water-logged agriculture area near village Garmala Ta. Matar  
(As on 28th December, 2009)

Plate 3.2 Salinity affected agriculture land in village Machhiel Ta. Matar  
(As on 18th January, 2010)
The average annual income per farmer in the year 1988 is reported as Rs. 1.44 lacs and it increased to Rs. 2.54 lacs in year 1998. The average annual income per farmer in the year 2008 dropped to Rs. 2.27 lacs. The variation of average annual income from agriculture in different villages in the study area is shown in Fig. 3.7. The farmers have started switching over to the mechanized farming in the area. There are 56.6% of the farmers who own the tractors, 21.7% having diesel engines and 38.6% having open well/tube-well for irrigation. Very less number of the farmers uses the livestock for farming activities. The literacy rate in the area is reported as 77.2%, with 22.4% of the family members having graduate level education. The educational scenario in the area reflected from the survey is shown in Fig. 3.8.

Survey carried out in Matar branch canal area reveal that the average annual income from agriculture has reduced in the last decade. A large numbers of the farmers have adopted mechanized farming and there is a need for the promotion of water efficient irrigation methods like drip and sprinkler systems for the crops other than paddy.

![Fig. 3.7 Average annual income (Rs.) per stakeholder in Matar branch canal area](image-url)
3.12 Summary and Conclusions

Almost all surface irrigation projects face the problems of water-logging in the canal head reaches and short supply of irrigation water in the tail reaches. Conjunctive use of canal water and groundwater is the ideal choice to address such issues. Groundwater development in the canal command areas has become the necessity for the water resources managers. Matar branch canal command area faces the similar problems hence is an appropriate choice for the study.